EXHIBIT "2"

Gonzalez Mower Accident Investigation

Introduction

This report summarizes our investigation of an accident that occurred to Marco Gonzalez on August 8, 2017 while operating a Wright Standing lawn mower. We were asked to write this report by Villari, Lentz & Lynam, LLC who represents Mr. Gonzalez in a legal matter related to the accident.

We conducted the following tasks as part of our investigation

1. Examined the incident mower at Picture Perfect Landscaping on July 2, 2018
2. Examined the incident mower in Avon, Massachusetts on April 5, 2019
3. Examined the incident mower in Avon, Massachusetts on March 22, 2019
4. Measured the deceleration time of the incident mower
5. Measured brake torque capabilities

We have also been provided with the following documents

1. January 16, 2019 Deposition of William Wright
2. December 10, 2018 Defendant Discovery Responses
3. September 26, 2018 Defendant's Initial Disclosure
4. December 18, 2018 Deposition of Martha Gonzalez
5. December 18, 2018 Deposition of Marco Gonzalez
6. Medical Records from the Philadelphia Hand Center
7. October 11, 2018 Plaintiff's Discovery Responses
8. September 21, 218 Plaintiff's Initial Disclosures
9. Reading Hospital Records
10. August 15, 2017 Audio Recording of Interview with Marco Gonzalez
11. Sign in sheet dated November 30, 2018 from an Initial Mower Inspection
12. February 5, 2019 Deposition of Calogero Sottosanti

Background

On August 8, 2017 Mr. Gonzalez was using a stand-up lawn mower made by Wright. It is a 52 inch-wide mower with 3 sets of blades. The model number is WS52FX691E, serial number 82866. It was manufactured in June of 2015. Figures 1 and 2 are photos of the mower showing its general appearance from the back (operator platform side) and the front, respectively.

Mr. Gonzalez hit a metal railing while using the mower, and was knocked off the mower. The blades decelerate to a stop automatically if the operator comes off the stand-up platform.

When Mr. Gonzalez fell off the mower he was in such a position that his hand went under the mower and contacted the blades while they were turning, even though they were in the process of decelerating. He suffered hand injuries at that time and eventually the thumb and index fingers of his left hand had to be amputated.

Figure 1. Photo of Wright Mower from Operator Platform Side

Figure 2. Photo of Wright Mower showing Front Side.

Mower Electrical Blade Control

The Wright Stander mower includes a power take-off (PTO) clutch system used to engage or disengage the cutting blades from the mower engine. The magnetic clutch is electrically operated and a simple drawing of a typical clutch is shown in Figure 3. The clutch is coupled to a 1” driveshaft from the mower engine. One side of the clutch is a pulley sheave, connected to the mower blades via a serpentine v-belt. The sheave does not rotate until the clutch engages with it when it is energized. When the PTO-on button is pulled by the operator, electrical power is provided to the clutch causing it to magnetically couple to the pulley sheave, allowing mechanical power from the engine to be transferred to the blades. When the PTO is shut off, the clutch disengages from the pulley sheave, and continues to provide some frictional resistance to aid in stopping the mower blades.

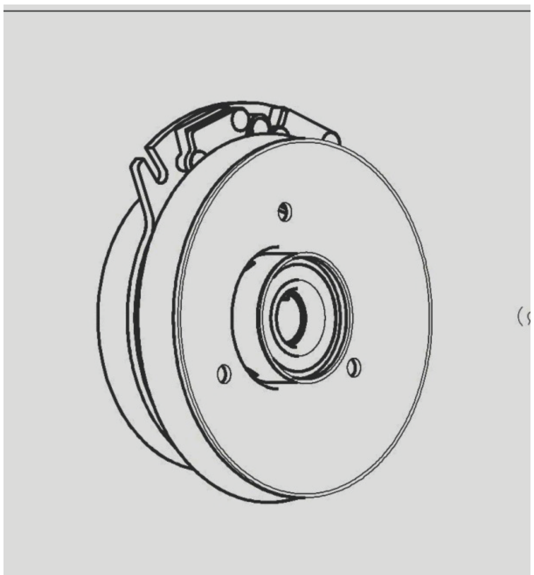

Figure 3. General Appearance of Blade Clutch

The schematic for the mower is shown in Figure 4. A simplified schematic is shown in Figure 5 and will be used to describe the operation of the electrical blade clutch control in the following discussions.

Energizing the blade clutch

The mower operator stands on a platform while using the mower. The platform has an “Operator Presence Control” switch (OPC) which closes due to the weight of the operator pushing the platform and switch in a downward direction. The OPC is connected so that one side is positive when the blade switch on the operator console is moved. That causes the other side of the switch to become positive as well and controls a relay that energizes the blade clutch. When the user has engaged the OPC and pulls the PTO switch seen below in Figure 6, the blades begin to rotate. Pushing the PTO, or disengaging from the OPC, de-energizes the clutch and the blades begin to stop rotating.

1. Control Levers
2. Stationary Handle Bar
3. Throttle
4. Choke
5. Digital Hour Meter
6. PTO Switch
7. Ignition Switch

Figure 6. Control Panel from the Wright Stander Instruction Manual

<u>De- energizing the blade clutch</u>

When the operator steps off the platform the OPC opens and a time delay module takes over. Instead of immediately de-energizing the clutch, the time delay module inserts a delay (about 0.5 seconds) and then de-energizes the clutch and the blades decelerate and stop rotating.

<u>Purpose of the Time Delay Module</u>

According to testimony of William Wright, this delay was inserted to solve a problem caused by the mowing of bumpy terrain. In that case the OPC would disengage the blades whenever a significant enough bump is encountered to interrupt mower operation. The time delay module keeps the relay closed when a bump is encountered, and allows the blades to continue rotating normally. When the operator steps off the platform the time delay module does not immediately open the relay. It opens the relay after a preset time period. According to documents provided by Wright, and Mr. Wright's deposition (page 83), the time delay is 0.5 ± 0.125 seconds (0.375-0.625). Mr. Wright also testified that on later mower models there is no time delay, but the OPC is moved to a different location. The change in location allows the OPC to open the relay as the operator leaves the platform, and therefore does not need to account for bumpy terrain with a delay.

Test data taken included in Appendix A of this report shows that the time delay that was installed in the mower at the time of the accident provided a time delay of approximately 0.360 seconds. The large peaks in the data traces are a result of the clutch coil inductance. The initial yellow and blue vertical lines correspond to the opening of the OPC and subsequent de-energization of the clutch coil respectively.

Blade Deceleration Measurement

Blade deceleration was measured with the aid of a digital timer and high-speed video camera. The digital timer measured time to an accuracy of 0.1 seconds. The timing was started when the operator stepped off the platform. The signal from the OPC was used to start timing. Video recording was made using an Olympus TG-5 camera recording at 480 frames per second. Figure 7 below is a snapshot from a typical video.

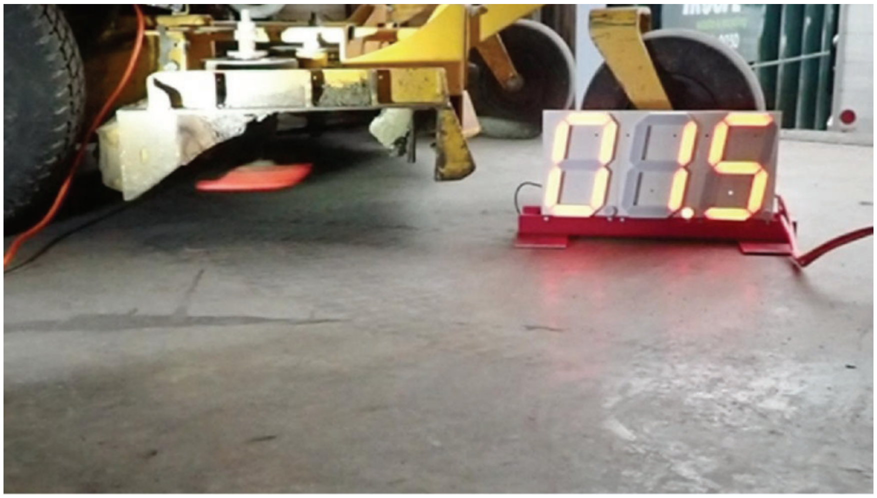

Figure 7. Test Video Snapshot

The digital timer is on the right side of the mower blades. The camera is aimed at the blades. Only the blade closest to the camera is visible and the red blur is the one blade tip that has been wrapped in red tape. The other blade tip has been wrapped in yellow tape.

Blade Deceleration Times

The clutch at the time of the incident was a Warner 5218-243 electric PTO clutch. The Wright part number for this clutch is 71410020. This clutch has a nominal static torque of 200 ft-lbs[1], which is the amount of torque required for the clutch to slip on the pulley sheave. When the clutch was electrically disengaged, we measured the resistance of rotation between the sheave and this clutch to be 3.75 ft-lbs. Using high speed video, we found that when the user steps off of the platform and triggers the OPC, the mower blades stopped in 3.9 seconds. With the OPC time delay defeated, the blades stopped in 3.5 seconds, an improvement of approximately 0.4 seconds. This is commensurate with the 0.36 second OPC delay measured in the oscilloscope data in appendix A.

We installed an Ogura GT3.5-MC08 clutch on the incident Wright Standup mower, and measured the time needed to stop the blades with this clutch. Ogura is a Japanese manufacturer of clutches similar in function to Warner products. In his deposition, Mr. Wright testified that his company has experimented with Ogura clutches, and even added Ogura

clutches to certain mowers in their lineup (page 39). A file named WMI_CLUTCH_HISTORY.PDF from the Wright Manufacturing website shows that an Ogura GT3.5 clutch is used on Wright WSZK2 52” and 61” mowers, serial numbers 75180 and higher[1]. According to Ogura’s website[2], the GT3.5-MC08 PTO clutch/brake has a static torque of 300 ft-lbs when electrically engaged. When electrically disengaged, we measured the braking resistance of the sheave to be 5.75 ft-lbs. Ogura’s installation documents state that braking torques can range from 2-10 ft-lbs depending on the model. 5.75 ft-lbs is a 53% increase in torque, when disengaged, versus the stock Warner electric PTO clutch. As would be expected, the Ogura clutch fitted-mower stopped faster than the stock clutch, at 3.5 seconds. With the OPC delay removed from the system, the mower stopped in 3.2 seconds. Switching from the Warner clutch, to the Ogura clutch without the OPC delay, reduces the blade stopping time by 0.7 seconds, from 3.9 seconds to 3.2 seconds. This is a reduction of 18% of stoppage time, with a simple drop-in replacement.

While 0.7 seconds difference in stopping time may not sound like a significant difference, analysis of the slow-motion videos show that the blades on the unmodified mower are rotating at approximately 738 RPM at 0.7 seconds before coming to a complete stop. This equates to a rotational kinetic energy of approximately 253 joules, for the entire system. This energy is the equivalent of being hit by the sharp edge of a non-rotating lawnmower blade moving at 51 miles per hour.

On page 37 of his deposition, Mr. Wright testified that as clutches age, their time to blade stoppage decreases. Since the Warner stock clutch tested was older and broken in, we can assume that it stops faster than it did when newly installed. On Page 72 of his deposition, Mr. Wright states that they allow mowers to leave the factory that take as long as 5.7 seconds to come to a stop. The Ogura clutch was brand new when tested, we can assume that its stopping ability will only improve with time and stop faster – increasing the performance gap between the Ogura and the Warner clutch. With use, the time to stoppage of the blades with the Ogura clutch will decrease.

Discussion of stopping torque

Figure 8 illustrates the braking behavior of the two clutches, Warner and Ogura. Here, we plot our measured angular velocities of the mower blades, measured via high-speed video, plotted versus time elapsed in the video. Each measurement started at 377 rad/s, and ended at 0 rad/s. The amount of clutch braking torque dictates the slope of the line, and thus changes the time for the blades to come to a stop. The data exhibit highly linear braking behavior, as is expected. Thus a linear model can be used to predict the system in other braking scenarios.

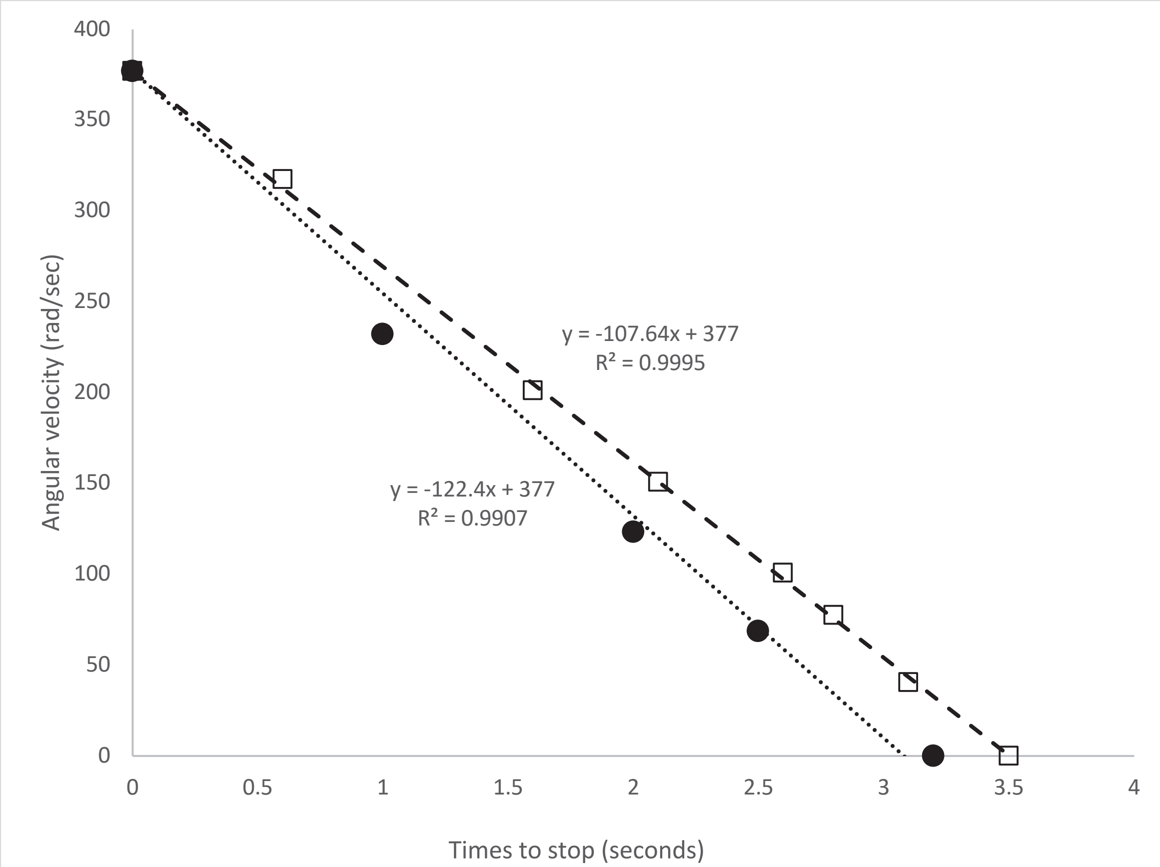

Figure 8: Angular velocity versus time; the Ogura clutch is represented by black circles, the Warner clutch by squares. Linear fits and R^2 values are to the left and right of each line.

The energy of a rotating system such as a lawn mower's blades and power transition elements can be represented by the following equation:

$$E_{system} = \sum \frac{1}{2} I\omega^2$$

where I is the moment of inertia, and ω is the angular velocity, of each component respectively. Using 377 rad/s as our initial angular velocity (3600 rpm), and estimating 0.085 kg-m^2 as the sum of all moments of inertia (clutch, pulleys, shafts, blades), the total rotational kinetic energy of the system is calculated to be 6013 joules.

Once the engine is cut, the PTO is shut off, or the OPC disengages power, the system must dissipate these 6013 joules in order for the blades to stop rotating. This energy is dissipated through torque times the rotation distance (radians) until stoppage. This is expressed by the equation:

$$E_{lost} = (\tau_{internal} + \tau_{brake}) \times \theta$$

Here $\tau_{internal}$ represents the sum of the torques resisting rotation which are inherent to the machine itself (frictional forces, belt forces, bearing losses etc). τ_{brake} is the torque applied by the brake/clutch system, and θ is the total amount of rotations (radians) through which the system rotates during deceleration to stopping.

For the system to stop rotating, E_{system} must equal E_{lost} , meaning all of the energy has been dissipated. We can calculate the amount of rotation θ for each clutch tested from the data in Figure 8, equal to 667.3 radians for the Warner clutch, and 553.9 radians for the Ogura. It was measured that the τ_{brake} for the Warner and Ogura clutches are 3.75 ft-lbs (5.08 N-m) and 5.75 ft-lbs (7.8 N-m), respectively. Therefore, for the Warner clutch:

$$6013 \text{ J} = (\tau_{\text{internal}} + 5.08) * 667.3$$

and for the Ogura clutch:

$$6013 \text{ J} = (\tau_{\text{internal}} + 7.8) * 553.9$$

Solving for $\tau_{internal}$ produces 3.93 N-m for the Warner clutch, and 3.06 N-m for the Ogura. For the purposes of this report, we will treat these numbers as upper and lower bounds of the "internal torque." It should be noted that these numbers are sensitive to changes in E_{system} as a function of the moment of inertia and θ. As the total energy in the system (E_{system}) increases, the numbers for $\tau_{internal}$ will increase and converge. Our 6013 J calculation is a conservative estimate; it accounts for the estimated moments of inertia of the components (clutch, pulley sheaves, blades, shafts), but cannot account for efficiency losses, inertial contributions of the belts, slippage, and other effects. The effects of θ are also significant on the $\tau_{internal}$ calculation. If either θ value changed by approximately 10%, our τ_{internal} values would be essentially the same. The closeness in our $\tau_{internal}$ calculations means that our mathematical model for the system is valid.

Alternate Clutch/Brake Designs

On page 47 of his deposition, Mr. Wright testified that he had never asked the brake/clutch manufacturers if stopping the blades sooner was possible with different products. He had relied on them to offer "the best clutch for a mower," (page 48) which is undirected and does not put any emphasis on safety.

Warner offers several products which should have been considered by Wright Manufacturing as alternatives to the Warner 5218-243 employed in the current design. Warner's website advertises a CMS 250 MagStop clutch with a 15 ft-lb (20.34 N-m) braking option[3]. In this case, 20.34 N-m is the value used for τ_{brake}, as described above. Recalling the equations for our two values of τ_{internal}:

$$E_{system} = E_{lost} = (\tau_{internal} + \tau_{brake}) \times \theta$$

$$6013 \text{ J} = (3.93 + 20.32) \times \theta$$
or
$$6013 \text{ J} = (3.06 + 20.32) \times \theta$$

Solving for θ in these two cases gives us 248 and 257.2 radians, respectively. These are equal to 1.32 to 1.36 seconds stopping time. By utilizing a clutch with 15 ft-lb braking force, we predict a stopping time of more than 2 seconds better than the stopping time of the stock Warner clutch.

The static torque (up to 250 ft-lbs) and horsepower capabilities of the MagStop clutches also seem to be appropriate for the Wright Stander. Like the Warner 5218-243 and the Ogura clutch, the CMS 250 MagStop operates at 12 V, with a steady state amperage of 6-7 A[4].

A second option would be to install an electromagnetic braking system, in addition to the existing clutch. Warner also manufactures a number of such brakes. A Warner PB-500 brake, for one example, could be coupled to the clutch sheave and provides 40 ft-lbs of braking force[5]. 40 ft-lbs (or 54.23 N-m) of braking torque would stop the system in a calculated time of approximately 0.55 seconds. A PB-500 magnet and armature can currently be purchased from PLC Central and Motion Industries for a combined retail price of $367, which is within range of the retail pricing of the Ogura and Warner clutches currently used by Wright Industries.

Although 0.55 seconds stopping time with 54.23 N-m of torque may sound extreme, it is not an unreasonable calculation. Kawasaki reports an output torque of 45 N-m at 3600 RPM for the FX691V engine[6] that powers the 52" Wright Stander. In our high-speed video measurements, this output torque accelerated the mower blades from zero to 3600 RPM in 0.88 seconds. It stands to reason that a higher braking torque (54.23 N-m) could stop the system in a faster time than the output torque (45 N-m) accelerates the system.

Conclusions

We make the following conclusions based on our examination and testing of the incident mower, our review of the documents, and our education, background, and training.

1. A clutch/brake with increased resistance torque, and removal of the time delay, would have reduced or prevented Mr. Gonzalez's injuries. A simple clutch swap, which increased the stopping torque from 3.75 ft-lbs to 5.75 ft-lbs, decreased the stopping time from 3.9 seconds to 3.2 seconds, an 18% reduction.

2. The design of the clutch/brake system in the Wright Stander WS52FX691E is defective, and neglected to emphasize operator safety. Mr. Wright testified that no effort was made to ask Warner nor test alternative clutches for decreased stopping time.

3. Alternative clutch/brake systems were available to Wright Manufacturing which would have decreased the stopping time. Such systems were not explored by Wright Manufacturing, despite their availability from their current clutch vendor, Warner.

4. The design of the OPC system in the Wright Stander WS52FX691E is defective. The time delay, as configured in the Wright Stander WS52FX691E that injured Mr. Gonzalez, is inherently unsafe and unnecessary. Wright Manufacturing has since changed their OPC design to not require a time delay.

Michael Tarkanian, P.E.

Donald Galler, P.E.

May 23, 2019

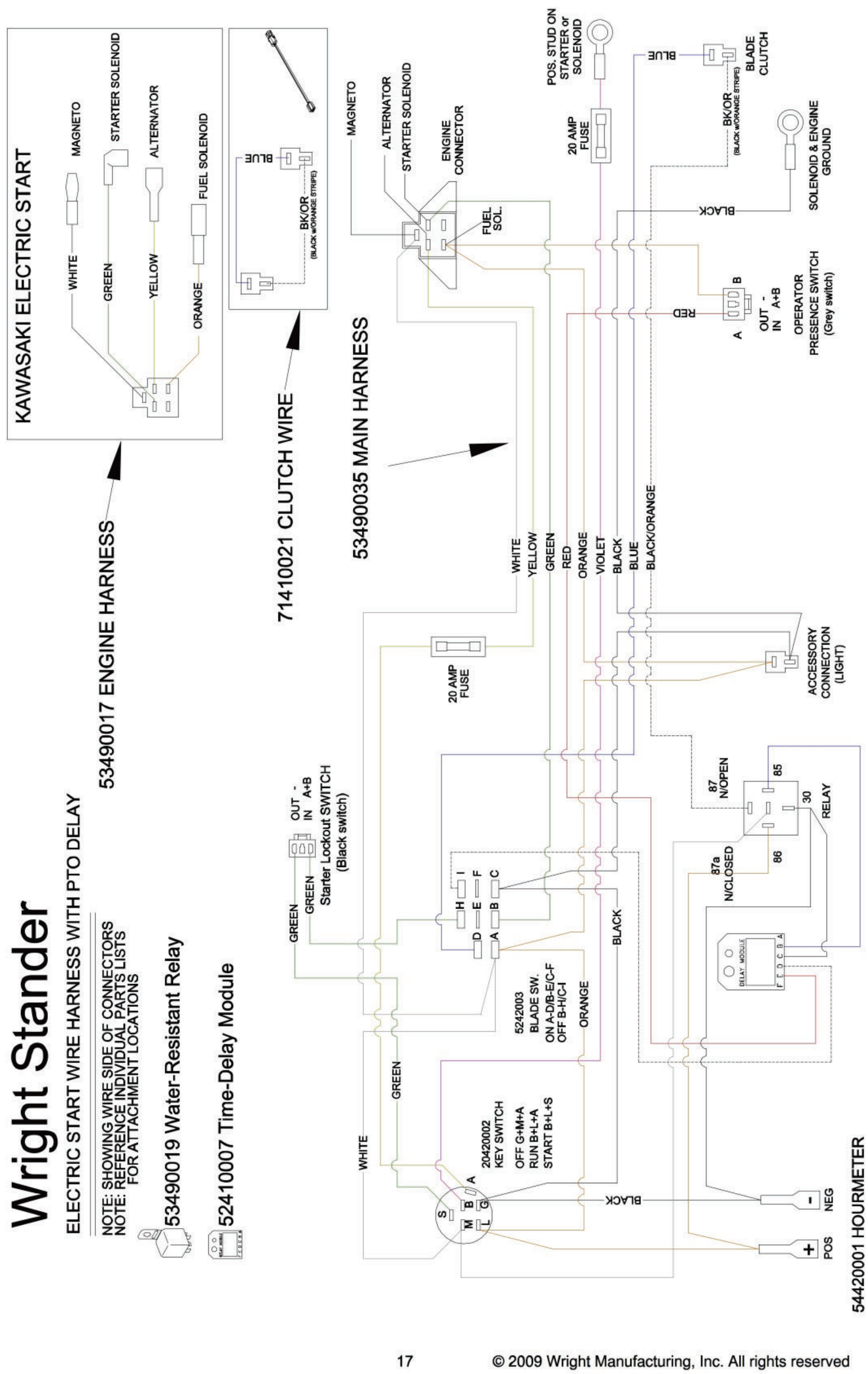

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Figure 4. Mower Schematic

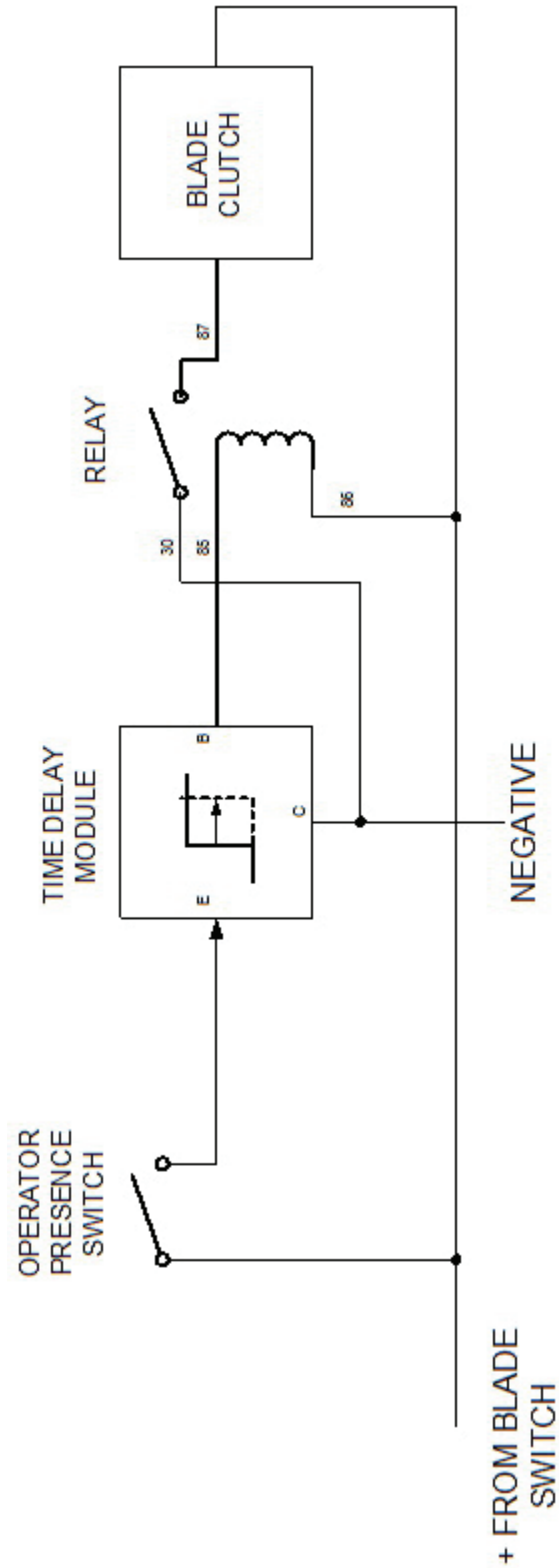


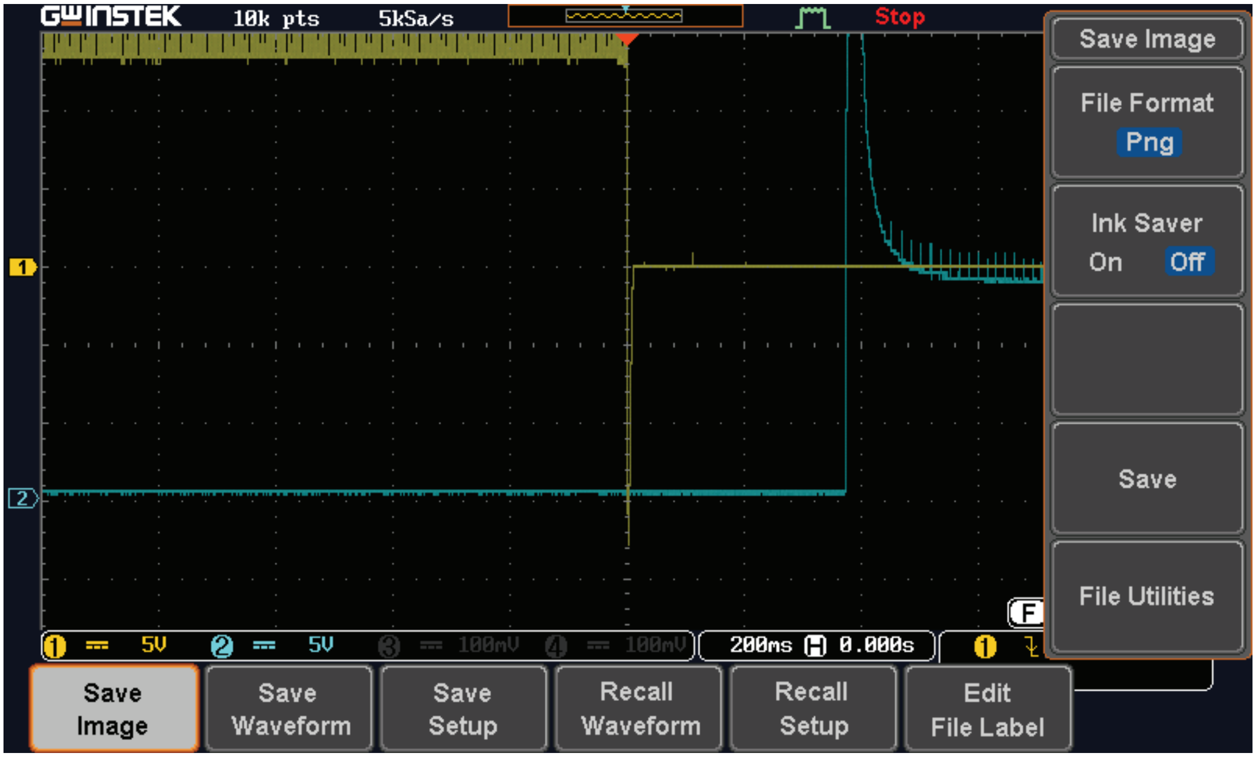
Figure 5. Simplified Blade Clutch Control

References

(1) https://www.wrightmfg.com/support/support_rsync_dir/MOWER-PARTS-USAGE-CHARTS/WMI_CLUTCH_HISTORY.PDF accessed on 4/12/19

(2) https://ogura-clutch.com/products.php?category=2&product=9.. accessed on 5/18/19
(3) https://www.warnerelectric.com/-/media/Files/Literature/Brand/warner-electric/related/brochures/p-1894-we.ashx accessed 5/18/19
(4) https://www.warnerelectric.com/-/media/Files/Literature/Brand/warner-electric/catalogs/p-1698-we.ashx accessed on 5/18/19
(5) https://www.warnerelectric.com/-/media/Files/Literature/Brand/warner-electric/catalogs/p-1264-we.ashx accessed on 5/18/19
(6) http://www.kawasakienginesusa.com/sites/default/files/test-data/Kawasaki%2520FX691V%2520Certified%2520Power%2520Rating.pdf accessed on 5/18/19

Appendix A
Installed Time Delay Measurement



July 31, 2019

VILLARI, LENTZ & LYNAM, LLC
100 North 20th Street, Suite 302
Philadelphia, PA 19103

Attn: Thomas A. Lynam

Re: Gonzalez v. Wright

Dear Mr. Lynam,

At your request we have reviewed the Defense's expert reports, and have prepared a rebuttal response to the reports of Mr. Danaher and Mr. Main.

We will address our rebuttals to the following points:

1. Both Mr. Danaher and Mr. Main rely on the fact that the subject mower is able to stop faster than the seven second ANSI B71.4 standard. Mr. Main asserts that blade stopping time is not a design criterion, that the mower is safe and not defective. We disagree. This document will show that a reduction in stopping time to less than 0.8 seconds is possible, safe, and effective, without damage to the Wright mower and without significant engineering redesign. In Mr. Wright's deposition (p. 48) he testified that Wright Manufacturing had made no effort to determine how fast the blades could stop, and that they relied upon Warner to provide them with the "best clutch" for their class of mower.

The ANSI B71.4 standards cited by Danaher and Main specify that the operator presence control must stop the blades from spinning within 7 seconds, but the standard also states that "stopping of the implement/attachment drive is for the protection of an operator **intentionally** leaving the operator's position while the implement/attachment drive is in operation. Operator-presence controls for the implement/attachment drive are not intended to protect bystanders from run-over or other accidents. Also, **they are not intended to protect the operator from sudden access to the blades, which would occur because of jumping or falling from the machine.**" (ANSI B71.4 2004 p. 71; 2012 p. 114; 2017 p. 112). Therefore, the B71.4 standard is not a relevant engineering benchmark when the operator **unintentionally** leaves or falls off of the mower, as was the case with Mr. Gonzalez. The consumer – or operator in this case -- should reasonably expect that the blades will stop before they can be reached when unintentionally falling off of the machine. An analogous example is the CPSC regulations controlling the length of consumer mower handles to make sure the blades stop before they can be touched.

2. On page 29 of Mr. Main's expert report, he writes that "plaintiff's experts Mr. Tarkanian and Mr. Galler suggest that the Warner CMS 250 MagStop clutch is an alternative clutch/brake that would stop in a predicted time of more than 2 seconds better than the stopping time of the stock Warner clutch. This clutch/brake design requires power to actuate. Power to actuate presents a potential unsafe failure mode because power is required to stop the blades. This

clutch should be disqualified for this reason alone." The point of our example of the CMS 250 MagStop clutch was to illustrate that various products were available from Warner that could have stopped the mower blades faster than the clutch installed on the Wright Stander in question. The CMS 250 MagStop was not meant to be the ONLY viable solution, but one of many possibilities. Additionally, unless Warner's product documentation is incorrect, we believe Mr. Main's assessment of the way the CMS 250 MagStop operates is incorrect. Warner's product catalog, accessed at https://www.warnerelectric.com/-/media/Files/Literature/Brand/warner-electric/catalogs/p-1698-we.ashx on July 28, 2019, states that "the MagStop clutch/brakes combine an electric friction clutch with a permanent magnet brake. Electric current applied to the clutch coil draws the armature to the rotating rotor, engaging the clutch and rotating the blade through the pulley. Stopping current flow to the coil causes the armature leaf springs to pull the backside of the armature (which acts as the braking surface) into contact with the permanent magnet braking surfaces so the braking torque generated by those magnets can stop the blade…" The is exactly the opposite of the scenario Mr. Main describes. Warner's description makes clear that power must be applied to engage the clutch and rotate the blades; loss of power engages the permanent magnets and the blades stop rotating.

3. On page 22 of Mr. Main's report, he writes that "Achieving a substantially faster stopping time would require major changes to the mower system. New, different, or stronger belts would likely be required, or a different drive system entirely. The clutch/brake supporting/mounting structure would likely need to be strengthened to counteract the increased forces applied by the clutch/brake." He continues on page 23, writing "minimizing the stopping time is not a design criterion. If it were, substantial design changes to commercial mowers would be required." We do not concur, and our testing and data show otherwise.

We tested Mr. Main's hypothesis that achieving substantially faster stopping times would require major changes to the mower system, by installing a Warner PB-1000 electromagnetic brake, much like the Warner PB-500 referenced in our original expert report. In our report, we calculated that the PB-500, at a maximum 40 ft-lbs (54.23 N-m) braking torque, could stop the Wright Stander in question in 0.55 seconds. Since Kawasaki reports a maximum torque output of 45 N-m (33.2 ft-lbs) at 3600 rpm for the engine installed on the Wright Stander, we assumed that we could safely STOP the blades with an equal and opposite braking torque of 45 N-m. If the machine was engineered by Wright to accelerate due to 45 N-m torque, it would equally be able to decelerate due to 45 N-m torque. After installing the PB-1000 and measuring the resistance of rotation to be approximately 5.5 ft-lbs, including the Ogura clutch from our original report, we adjusted the voltage and current to the electromagnetic brake to exert approximately 27.5 ft-lbs of torque, totaling 33 ft-lbs (or 45 N-m) of torque resisting rotation of the blades. The signal to engage the brake was coupled to the OPC: when the user stepped off of the platform, the mower clutch was disengaged and the PB-1000 was engaged, simultaneously. The OPC time delay was removed in this testing. **Using the PB-1000 brake to create a total of 45 N-m braking torque, we were able to stop the Wright Stander in 0.78 seconds.**

No belts were broken, no bolts were sheared, no blades were thrown, no costly engineering redesigns were required. On page 30 on his report, Mr. Main writes that “such an abrupt stopping application at the sheave would cause the drive belt to fly off on the idler side.” Our testing showed that this is not the case. In figure 1, screenshots of the high-speed video taken to measure the time to stop, we see the blades rotating at full speed at 0.00 seconds, and the blades fully stopped with the clock indicating 0.8 seconds[1].

(a)

(b)

Figure 1: (a) blades rotating at full-throttle at 0.0 seconds, and (b) the blades fully stopped with the clock showing 0.8 seconds.

The armature of the PB-1000 was mounted to the central blade pulley sheave, as seen in Figure 2. The PB-1000 coil was mounted to a steel plate, which was then attached to the frame of the Wright Stander, without any modification, with c-clamps.

[1] Note that in the code used to trigger the timer relative to the OPC, the clock begins timing at 0.1 seconds, rather than 0.0 seconds. In the highspeed video, we measured the blades stopped at 0.88 seconds, which is actually 0.78 seconds when accounting for the extra 0.1 seconds due to the clock code.

Figure 2: The Warner PB-1000 brake mounted to the center blade sheave

The electrical requirements of the additional powered brake were approximately 1.4 A and 2 V for the braking period of less than 1 second.

On page 29 of Mr. Main's July 24, 2019 report he opines that the brake we used represents an unsafe design because power is required to actuate the brake. We have the following comments with respect to that opinion:

- The mower braking time would not be any less than the present standard time (approximately 4 seconds) if the additional brake should fail, assuming the existing brake is still functional.
- Loose wires, braking coil failures and electrical control failures are detectable conditions. If the additional brake were to become electrically non-functional because of a detectable failure prior to braking then one of the following actions could be taken:

    - Engine shut down
    - Indicator alerting operator of a high-speed braking failure.

- The power required for the additional brake would not be a burden on the mower's existing electrical system. The power requirements of the additional brake we used are modest as described above. The mower was delivered to us with an Exide GT-R battery that has 25 minutes of capacity at 25 A. These figures equate to 10.4 A-hours. The brake requirements of 1.4 A for 1 second are only 0.00038 A-hours which is roughly 25,000 times less than the battery capacity.

- The power required for the additional brake could be stored in additional energy storage devices, such as capacitors or small rechargeable batteries, for the sole use by the additional brake. This would isolate the brake energy from the mower's electrical system and provide an additional level of failure protection.

4. On page 30, Mr. Main writes that "Plaintiff's expert Mr. Vigilante estimated that a fall from the mower would occur in 0.6 seconds. Assuming this value is close to accurate, even in the best circumstance, the Tarkanian-Galler or Sevart alternative designs would not sufficiently reduce the stopping time to prevent or reduce Mr. Gonzalez's injury." It is now clear, with the 0.78 second stopping time we achieved with minimal engineering changes to the mower, that the stopping time could have been reduced sufficiently to prevent or reduce Mr. Gonzalez's injury. We agree, that with the as-designed Wright Stander stopping time measured to be 3.86 seconds, Mr. Gonzalez had little chance to avoid injury. But the difference between a fall of 0.6 seconds and a measured and demonstrated stopping time of 0.78 seconds would have given Mr. Gonzalez a much better chance of avoiding injury. On page 1 of his report, Mr. Main summarizes that "in no case is any alternative design sufficiently practical to stop the mower blades fast enough to prevent the injury to Mr. Gonzalez." Our work here shows that Mr. Main has no basis to make this claim.

We stand by our conclusion that the Wright Stander design is defective: our original report showed that we could stop the mower blades more quickly with a higher torque clutch; our work related to this rebuttal showed that the addition of a complementary braking system could stop the system in as little as 0.78 seconds. By Mr. Wright's own admission, Wright Manufacturing did no testing or research to determine how fast blades could be stopped. As mentioned in our original report, the cost of the additional brake is small relative to the overall cost of the mower, and is worth the elimination of the risk of blade contact.

Sincerely,

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Fall & Spring: '07 - present

3.014 Materials Laboratory
Fall: '09 – '12

3.094: Materials in Human Experience
Spring: '07 – present

3A04 Physical Metallurgy & Blacksmithing
Freshman Advising Seminar
Academic Year '06-'07 – present

Introduction to Welding
Introduction to Metal Casting
Introduction to Blacksmithing
IAP '07 - present

EC.720/2.722J D-Lab: Design
Design Mentor
Spring :'09 – 2017

UROP (Undergraduate Research Opportunity) Advisor
Fall: '09 - present

MADMEC
Energy & Environmental Prototyping Contest
Summer: '07 – present

MIT DMSE Senior Thesis Advisor
2013, 2016, 2017

MIT Department of Mechanical Engineering Senior Thesis Advisor
2017, 2018

Industry Experience:

Massachusetts Materials Technology LLC; Cambridge, MA
Co-founder
2014 - 2106

Bostik, Inc., Middleton, MA
Applications Specialist, Research and Development
2005 – 2006

Rhombus Technologies, Inc., Cambridge, MA
Co-founder
2003 - 2005

Z Corporation, Burlington, MA
Materials Research Scientist
2000 - 2001

Recent Academic Research:
Mechanical properties of forge welded steels
Jan 2018 -- present

Contact mechanics and mechanical properties of ductile metals
Jan 2015 -- January 2017

Chemistry and Processing of Damascus/Wootz steel
February 2015 – present

Project leader on joint DMSE-Tiffany & Co. research on platinum, sterling silver and stainless powder metallurgy techniques
June 2012 – June 2013

Mechanical properties and deformation characteristics of CuAg alloys
March 2010 – June 2013

3D printing refractory materials for direct fabrication of metal casting
molds for iron, steel, and titanium.
Sept 2009 – present

Recent Industrial Consulting (Materials & Process Development, Failure Analysis):

Consultant/Advisor for metal 3D printing materials and processes
Desktop Metal (3D printing)

Consultant/Advisor for fiber optic device manufacturing
AFFOA: Advanced Functional Fibers of America

Consultant/Advisor for manufacturing and characterization of battery electrodes
Form Energy, Inc.

Evaluation of helium deposits and extraction possibilities
Deutsche Bank

Failure analysis of a fractured CPVC water pipe
Retained on behalf of Archdiocese of Boston/P.J. Kennedy & Sons Inc.

Evaluation and process development of "Castable" 3d-printing foundry material
Formlabs (3D Printing)

Corrosion and hydrogen embrittlement of high strength Cessna engine bolts
Failure analysis of fractured landing gear
Cape Air

Design of a chuck for welding wear-protection studs
Fraser, Molloy & Associates, LLC

Alloy selection and design for cardiac cryoablation tools
AtriCure, Inc.

Design of experiments and testing of equine fracture repair implants
Tufts Veterinary School

Design of experiments and testing of stainless and titanium surgical implants
KYON Incorporated

Failure analysis of angle stop plumbing fittings
Chelsea Construction Corporation

Testing and evaluation of a drying device for stainless razors
ToiletTree Products, Inc.

Recent Consulting (Litigation):

Evaluation of zinc creep and fastener technology in Philips Sonicare toothbrushes (dismissed)
Class action suit v. Philips Electronics North America
Retained by Philips Electronics North America, Sullivan & Cromwell LLP

Dezincification of a 60/40 brass wye strainer (deposed, settled)
Allianz a/s/o Wright Services v. Watts Regulator Co
Retained by Watts Water Technologies, RivkenRadler LLP

Failure of vacuum tables for composite layup fabrication (deposed, settled)
Fives Machining Inc v. Graphic Parts International
Retained by Fives Machining Inc, Gloor Group LLP

Injury due to failure of a log splitter torsion spring (pending)
Zimmerman v. Generac Power Systems
Retained by plaintiff; Anderson, Moschetti & Taffany, PLLC

House fire from a wood burning fireplace insert (pending)
Safety Insurance v. The Fireplace Center
Retained by The Fireplace Center, Prince Lobel Tye LLP

Dezincification of 60/40 brass flow measurement ball valve (dismissed)
Allure Homeowners Association v. Watts Regulator Company
Retained by Watts Water Technologies, Alston & Bird LLP

Failure of FloodSafe leak detection plumbing product (pending)
Class action suit v. Watts Regulator Company
Retained by Watts Water Technologies, Alston & Bird LLP

Failure of a cooling tower and heat exchanger; copper corrosion (settled)
Affiliated FM Insurance a/s/o Jordan Health Systems v. Clearwater Technologies
Retained by Clearwater Technologies, Duggan & Gianacoplos LLC

Publications:

1. Dorothy Hosler, Sandra L. Burkett, and Michael J. Tarkanian, "Prehistoric Polymers: Rubber Processing in Ancient Mesoamerica," *Science* **294**: 1988-1991 (1999).

2. Michael J. Tarkanian, 3,500 Years Before Goodyear: Rubber Processing in Ancient Mesoamerica, MIT Bachelor of Science Thesis (June 2000).

3. Michael J. Tarkanian and Dorothy Hosler, "La elaboración de Hule en Mesoamérica," *Arqueologia Mexicana* **8**, 54-57 (August 2000).

4. Michael J. Tarkanian and Dorothy Hosler, An Ancient Tradition Continued: Modern Rubber Processing in Mexico, in *The Sport of Life and Death: The Mesoamerican Ballgame* (The Mint Museum of Art, Charlotte, NC, 2001).
5. Michael J. Tarkanian, Prehistoric Polymer Engineering: A Study of Rubber Technology in the Americas. MIT Master of Science Thesis (2003).
6. Michael J. Tarkanian. "Rubber Processing and Use in Ancient Mesoamerica." Paper presented at the 69th Annual Meeting of the Society for American Archaeology, Salt Lake City, UT (April 2005).
7. Michael J. Tarkanian. "Tres milenios antes de Goodyear: el hule en Mesoamérica" Paper presented at Las Sociedades Complejas del Occidente de México en el Mundo Mesoamericano: Homenaje al Dr. Phil C. Weigand, Museo Regional De Guadalajara (August 2006).
8. Michael J. Tarkanian and Dorothy Hosler. "Aspects of the Metallurgy of Calixtlahuaca, Estado de Mexico." Paper presented at the 55th Annual International Congress of Americanists, Mexico City (July 2009).
9. Michael J Tarkanian and Dorothy Hosler, America's First Polymer Scientists: Rubber Processing, Use, and Transport in Ancient Mesoamerica. *Latin American Antiquity* **22**: 469-486 (2011).
10. Diego D Quinteros, José M. García-López, Michael Tarkanian, Louise S. Maranda, Kirstin Bubeck, Michael P. Kowaleski, In Vitro Biomechanical Evaluation and Comparison of a new prototype Locking Compression Plate and Limited-Contact Dynamic Compression Plate for Equine Fracture Repair. *Veterinary and Comparative Orthopaedics and Traumatology* **25**: 273-280 (2012).
11. J. Haupt, J.M. Garcia-Lopez, M.J. Tarkanian, and R.J. Boudrieau, In Vitro Biomechanical Evaluation of a Locking Compression Plate and a Novel Monocortical Locking Plate System in an Equine Fracture Model. *Veterinary Surgery*, **42**(7):E93 (2013).
12. Michael J. Tarkanian and Mary Caulfield "Designing for Success: Hands-on Engineering & Communication in MIT's Department of Materials Science and Engineering." Paper presented at the 9th International CDIO Conference, Cambridge, MA (2013, June).
13. Steven D Palkovic, Brendon M Willey, Michael J Tarkanian, and Simon C Bellemare, Measuring variations in mechanical properties across and electric-resistance-welded (ERW) pipe seam with a portable device. *Journal of Pipeline Engineering,* vol **14,** no. 2: 79-89 (2015)
14. Steven D. Palkovic, Michael J. Tarkanian, Brendon M. Willey, Kotaro Taniguchi, and Simon C. Bellemare."Measuring variations in mechanical properties across an electric resistance welded (ERW) pipe seam with a portable device." Paper presented at the Unpiggable Pipelines Solutions Forum, Houston, TX (May 2015).

15. Michael J. Tarkanian, Steven D. Palkovic, Brendon M. Willey, Kotaro Taniguchi, and Simon C. Bellemare. "Measurement of mechanical properties of steel pipelines with a portable NDT device." Paper presented at the Aging Pipelines Conference, Ostend, Belgium (Oct 2015).

16. Michael J. Tarkanian, Steven D. Palkovic, Brendon M. Willey, Kotaro Taniguchi, and Simon C. Bellemare. "A portable NDT device for mechanical properties of pipelines during integrity digs." Paper presented at the Pipeline Pigging and Integrity Management Conference, Houston, TX (Feb 2016).

17. Samuel Wagstaff, Bradley Nakanishi, Ian Chesser, Mary Elizabeth Wagner, Michael Tarkanian. "A Study on the Reproduction of Genuine Damascus Steel Blades." Paper presented at the TMS Annual Meeting & Exhibition, Nashville, TN (Feb 2016).

18. Michael Tarkanian, Steven Palkovic, Kotaro Taniguchi, Phillip Soucy and Simon Bellemare. "Yield, Tensile Strength and Fracture Toughness Evolution Across Welded Joints." Paper presented at FABTECH American Welding Society Professional Program, Las Vegas, NV (November 17, 2016).

19. Michael Tarkanian and Elizabeth Paris, "An evaluation of stingless bee wax as a pattern material in Mesoamerican investment casting." Paper presented at the Society for American Archaeology, Vancouver, BC (March 31, 2017).

20. In Press: Biomechanical Comparison of Three Crural Fascia Repair Techniques for Tibial Tuberosity Advancement Surgery. In *Veterinary and Comparative Orthopaedics and Traumatology*.

Patents:

1. U.S. Patent #9,933,346, "Contact Mechanic Tests using Stylus Alignment to Probe Material Properties," April 3, 2018.

2. U.S. Patent #9,897,523, "Contact Mechanic Tests using Stylus Alignment to Probe Material Properties," February 20, 2018.

3. U.S. Patent #8,211,226, "Cement-Based Materials System for Producing Ferrous Castings Using a Three-Dimensional Printer," July 3, 2012.

4. U.S. Patent #7,550,518, "Methods and compositions for three-dimensional printing of solid objects," June 23, 2009.

5. Korean Patent #1020030009435, "Compositions for Three-Dimensional Printing of Solid Objects", January 2003.

Awards:

MIT School of Engineering Infinite Mile Award for Excellence, 2012
MIT Excellence Award, 2009: "Serving the Client"
Best Thesis, 2000, Department of Materials Science and Engineering, MIT

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FAX: 617-253-9451	
Email: dgaller@mit.edu	Email: d.galler@comcast.net

TECHNICAL INTERESTS

Electrical and electronic failure analysis. Power electronics and electric machinery. Power supplies and instrumentation for welding and materials processing applications. Computer programming for engineering analysis and control systems. Measurement and signal processing in power electronic applications.

EDUCATION

- BS in Electrical Engineering, Northeastern University - 1976
- MS in Electrical Engineering, University of Connecticut - 1979
- Graduate Course 3.37 - Welding and Joining, MIT - 1994
- Instructor for Summer Course 3.70 - Welding Power Supplies, MIT - 1995
- Scanning Electron Microscope Training Instructor - 2000

EMPLOYMENT SUMMARY

- Research Engineer:
  The Materials Science Welding Laboratory, MIT, Cambridge, Massachusetts 1995 - present
- Project Manager:
  Simpson, Gumpertz & Heger, Arlington, Massachusetts 1994 - 1995
- Managing Engineer:
  Failure Analysis Associates, Westborough, Massachusetts 1991 - 1994
- Senior Engineer:
  Failure Analysis Associates, Westborough, Massachusetts 1988 - 1991
- Senior Engineer:
  Alexander Kusko Inc., Needham Heights, Massachusetts 1979 - 1988

EXPERIENCE

Patent Investigations

Analysis of electrochemical failure in the flexible circuit connections of Ink-Jet printer cartridges.

Reverse engineering of microcomputer programs for taper-cut electrical discharge machining.

Demodulation and decoding of RFID tag transmissions.

Measurement of magnetization patterns in small brushless dc motors.

Low Level Program testing of computer VGA display technologies.

Failure Analysis

Failure investigation of Solid-State control element for truck-mounted refrigeration equipment.

Aircraft Accident Investigation Handbook for Electronic Hardware prepared for Wright-Patterson AFB

Scanning Electron Microscope (SEM) analysis of circuit board failures caused by thermal joint stress.

Failure analysis of commercial battery charging circuit for consumer appliances.

Investigation of the August 1990 Seaport Substation Outage in New York City for Con-Edison.

Control Systems

Control algorithms for a 4 MW thyristor rectifier for transit vehicle testing. For the DOT/TTC, Pueblo, CO.

Microcomputer-based data acquisition and signal processing for railroad track quality analysis.

Design review of 8086-based propulsion control system for BART C-car.

Design of phase locked loop control circuits for line synchronization of 60 Hz UPS.

Application of Linear Quadratic Regulator for nonlinear control channels in F100 jet engine.

Power Electronics and Power Conversion

Designed and constructed water-cooled high performance power supplies for welding research. MIT.

Wideband power amplifiers using hybrid power op-amps for MHD stirring experiments. MIT.

Propulsion system for the Magneplane concept definition study for the National Maglev Initiative.

Design review of emergency generators controls at ten Nuclear Power Plants. Transamerica Delaval.

Wideband measurement of DC-side harmonics on the BART 1000 V Traction Power System.

PROFESSIONAL AFFILIATIONS

- Registered Professional Engineer (Electrical): Massachusetts No. 32121
- Member, Institute of Electrical and Electronics Engineers
- Member, American Society for Materials
- Member, National Fire Protection Association

COMPUTER HARDWARE AND SOFTWARE

Over 25 years of experience in programming, engineering computation and hardware-related activities especially in real-time systems applications. Specific programming experience in C, FORTRAN, BASIC and an assortment of classical assembly languages (8088, Z80, PDP-11, 80x86 family). C programmed embedded microcontroller applications. Low level hardware control of VGA displays and other subsystems on Personal Computers. Magnetic field analysis code – Visual Basic. C programmed pulse generation control of welding power supply. C programmed microcomputer for receiving / transmitting GPS signals in 27 Mhz Radio Control band.

PUBLICATIONS

1. "Energy Efficient Control of AC Induction Motor-Driven Vehicles", Proceedings of the 1980 IEEE/IAS Annual Meeting, Cincinnati, OH, October 1980.

2. "A Fast Response Transistor Current Regulator for Welding Research", Proceedings of the 1981 IEEE/IAS Annual Meeting, Philadelphia, PA, October 1981. (with J. Converti)

3. "Potential Use of Extended Speed Range AC Drives for Cranes and Hoists", Proceedings of the 1982 Control Engineering Conference, Chicago, IL, May 1982. (with A. Kusko)

4. "Survey of Microprocessors in Industrial Motor Drive Systems", Proceedings of the 1982 IEEE/IAS Annual Meeting, San Francisco, CA, October 1982. (with A. Kusko)

5. "Control Means for Minimization of Losses in AC and DC Motor Drives", IEEE Transactions on Industrial Application, July/August 1983. (with A. Kusko)

6. "Selecting Electric Motor Drives for the Chemical Processing Industries", Chemical Processing Magazine, September 1986. (with A. Kusko)

7. "McGraw Hill Standard Handbook for Electrical Engineers" 12th edition, Section 28 Industrial Electronics.

8. "The Shocking Truth of Accelerometer Selection", Machine Design Magazine, July 6, 1989 Issue. (with A. Booth)

9. "Maintenance of Power Electronic Equipment", Electrical Construction and Maintenance, October 1989. (with A. Kusko)

10. "Nonlinear Loading of Static and Rotating Uninterruptible Power Supplies (UPS),"International Power and Engineering Consultants Conference, Tokyo, Japan, April 1990 (with A. Kusko and S. M. Peeran)

11. "Output Impedance of PWM UPS Inverters - Feedback versus Filters," Proceedings, Institute of Electrical and Electronics - Industry Application Society Annual Meeting, Seattle, Washington, October 1990 (with A. Kusko and N. Medora)

12. "Causes of Aircraft Electrical Failures," National Aerospace Electronics Conference, Dayton, Ohio, May 20-24 1991 (with G. Slenski)

13. "Improved Rail-Fastener for Stray Current Control," Proceedings, American Society for Testing and Materials, Symposium on Corrosion Forms and Controls for Infrastructure, San Diego, California, November 1991 (with P. L. Todd)

14. "Aircraft Accident Investigation Handbook for Electronic Hardware," Proceedings of the 1992 Conference of the International Society of Air Safety Investigators, Dallas Texas (with G. Slenski).

15. "Measurement of Permanent Magnet Rotor Magnetization Characteristics of DC Brushless Motors," Proceedings, Institute of Electrical and Electronics - Industry Application Society Annual Meeting, 1992 (with A. Kusko, N. Medora)

16. "Impact of Source Impedance on the Operation of Power Semiconductor Converters", May 4, 1993 Meeting of the IEEE Power Engineering Society, Boston Chapter. (with A. Kusko)

17. "The CRC Press Electrical Engineering Handbook", Article 61.2 - Motors. 1st Edition. 1993, The CRC Press.

18. "Magnetic Fields from a Maglev Motor Winding", May 1993 Maglev Conference, Argonne National Laboratories. (with W. J. Greenberg)

19. "The CRC Press Electrical Engineering Handbook", Article 66.2 - Motors. 1997, The CRC Press.

20. "Electronic Failure Analysis Handbook", Chapter 15 - Wires and Cables (with G. Slenski), also contributed to Chapter 14 - Printed Wiring Assemblies, Chapter 16 - Switches and Relays, Chapter 18 - Components. McGraw-Hill, Edited by Perry L. Martin, 1999.

21. "The McGraw-Hill Standard Handbook for Electrical Engineers", 14th Edition, 1999. Section 22 Electronics. Edited by D. G. Fink, H. W. Beaty.

22. "Fire Safety of Grounded Corrugated Stainless Steel Tubing in a Structure Energized by Lightning", B. Haslam, D. Galler, T. W. Eagar. FireTechnology, February 2016. SpringerLink.

23. "Cellular immunologic responses to cochlear implantation in the human", J.B. Nadol, J.T. O'Malley, B.J. Burgess, D. Galler. Hearing Research, December 2014. Elsevier